

WORKSHOP ON EMERGING SCIENTIFIC OPPORTUNITIES USING X-RAY IMAGING



Introduction to Workshop

Francesco De Carlo (Advanced Photon Source)

Wah Keat Lee (Advanced Photon Source)

Gabrielle Long (Advanced Photon Source)

Stuart R. Stock (Northwestern Univ. Medical School)

Workshop Chairs

August 29 – September 1, 2004, The Abbey, Fontana, Lake Geneva Area, WI



WORKSHOP ON EMERGING SCIENTIFIC OPPORTUNITIES USING X-RAY IMAGING

Is a part of a study to explore future scientific directions for the Advanced Photon Source (APS)

Chair: Gopal Shenoy (APS/ANL)

Co-Chair: Sunil Sinha (UCSB/LANL)

August 29 – September 1, 2004, The Abbey, Fontana, Lake Geneva Area, WI



Workshops held at the APS

1 Future Directions in Synchrotron Environmental Science

(APS Users' Meeting, May 4, 2004, APS)

Chairs: Steve Sutton, Ken Kemner, Shelly Kelly

2 Emerging Areas in Biological Crystallography

(Dates July 26-28, 2004, APS)

Chairs: Wayne Hendrickson, John Helliwell

3 Frontier Science Using Soft X-rays

(August 5-6, 2004, APS)

Organizers: Richard Rosenberg, Juan Carlos Campuzano

4 Science with High-Energy X-rays

(August 9-10, 2004, APS)

Chair: Dean Haeffner

5 Membrane Science

(August 17-18, 2004, APS)

Chairs: Millicent Firestone, Tom Irving, Jin Wang, Randall Winans

Workshops at the Abbey in Lake Geneva, WI



6 Emerging Scientific Opportunities with X-ray Imaging
(August 29 to September 1, 2004, Lake Geneva)
Chairs: Francesco De Carlo, Wah Keat Lee,
Gabrielle Long, Stuart Stock

7 Time Domain Science Using X-ray Techniques

(August 29 to September 1, 2004, Lake Geneva)

Chairs: Lin Chen, David Reis, Steve Milton, Linda Young

8 Mesoscopic and Nanoscopic Science

(August 29 to September 1, 2004, Lake Geneva)

Chairs: Sunil Sinha, Eric Isaacs

9 Nanomagnetism Using X-ray Techniques

(August 29 to September 1, 2004, Lake Geneva)

Chairs: Sam Bader, Laura Lewis, George Srajer

Workshop Scope

- Science explored using x-ray imaging is truly multi-disciplinary.
- New opportunities in applying x-ray imaging are scientifically and technologically exciting and significant.
- Areas of science where x-ray imaging techniques are potentially useful:
 - Materials Science and Engineering
 - Life Science and Medicine
 - Molecular and Environmental Science
- The area of Coherent Diffractive Imaging provides newer opportunities at the Third Generation Facilities which will impact future experimental programs at the X-ray FELs.



Challenges

What are the
Grand Challenges
in Science and Technology
which can be addressed by
X-ray Imaging Techniques ?





WORKSHOP ON EMERGING SCIENTIFIC OPPORTUNITIES USING X-RAY IMAGING

A Small Sampling of Frontier Scientific and Technology Problems Using X-ray Imaging

Spatial resolution -> 1 μm over fields of view of 10 mm (3D)

Life Sciences: In vivo longitudinal characterization of biological structures
Real time observation of physiological processes

Soft tissue discrimination approaching that of MRI

Materials: Damage initiation, accumulation in composites
Fatigue crack studies in metals
Phase transformation kinetics

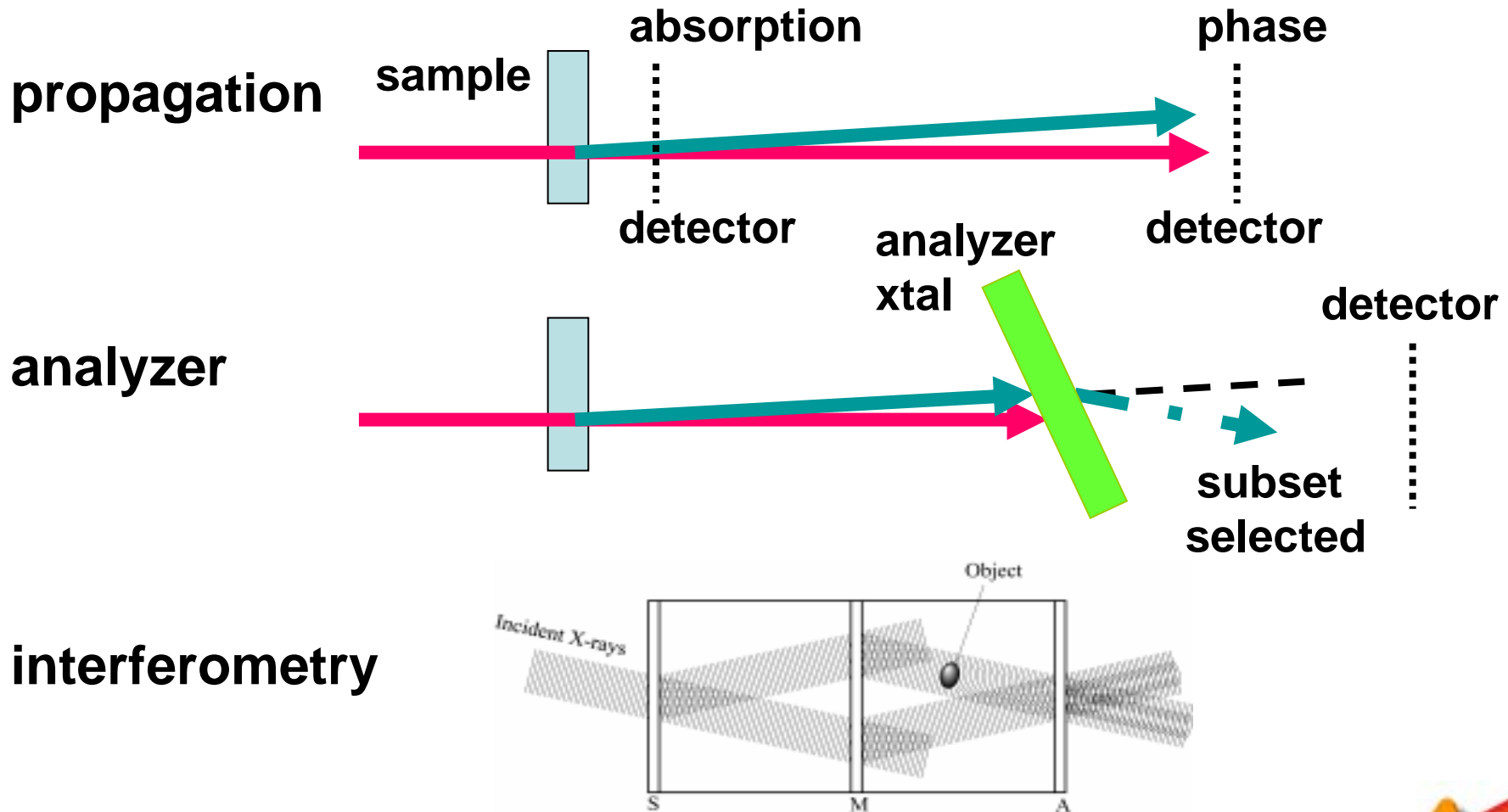
Complex Systems: Multi-phase fluid flow
Environmental degradation of construction materials

*.....and this Workshop Will Identify
Many More Opportunities of Significance
For the Next 5-10 Years.*

August 29 – September 1, 2004, The Abbey, Fontana, Lake Geneva Area, WI



Ex. 1 X-ray phase imaging



WORKSHOP ON EMERGING SCIENTIFIC OPPORTUNITIES USING X-RAY IMAGING

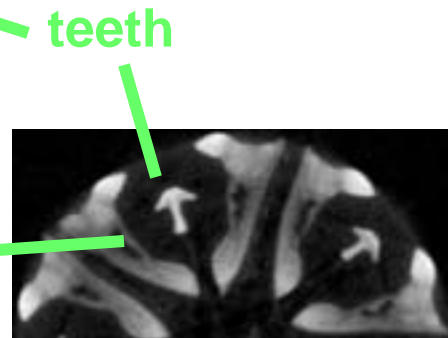
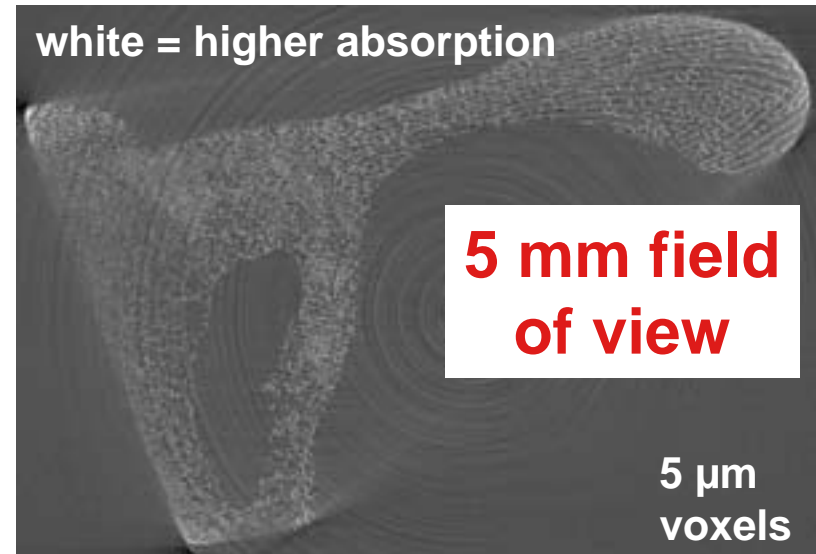
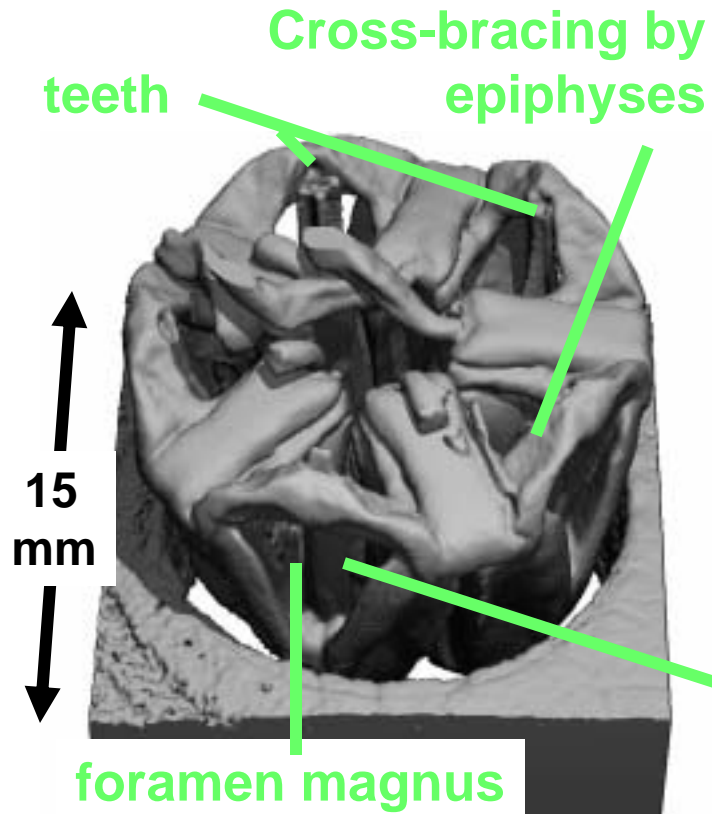
Phase imaging with grating interferometer Slide 1,
contact T. Weitkamp SLS tim.m.weitkamp@psi.ch

August 29 – September 1, 2004, The Abbey, Fontana, Lake Geneva Area, WI

WORKSHOP ON EMERGING SCIENTIFIC OPPORTUNITIES USING X-RAY IMAGING

Phase imaging with grating interferometer Slide 2,
contact T. Weitkamp SLS tim.m.weitkamp@psi.ch

Ex. 2: Wide field + high resolution



Need 1 μ m voxels,
same signal/noise,
entire field of view



Need larger CCD, improved optics.

Need to improve understanding of S/N, effect of (in)stability of beam, mechanical components.

Improved understanding of phase effects on microCT reconstructions.

Larger # projections & reconstruction matrix requires attention to rate slices can be reconstructed, to data storage and back up.

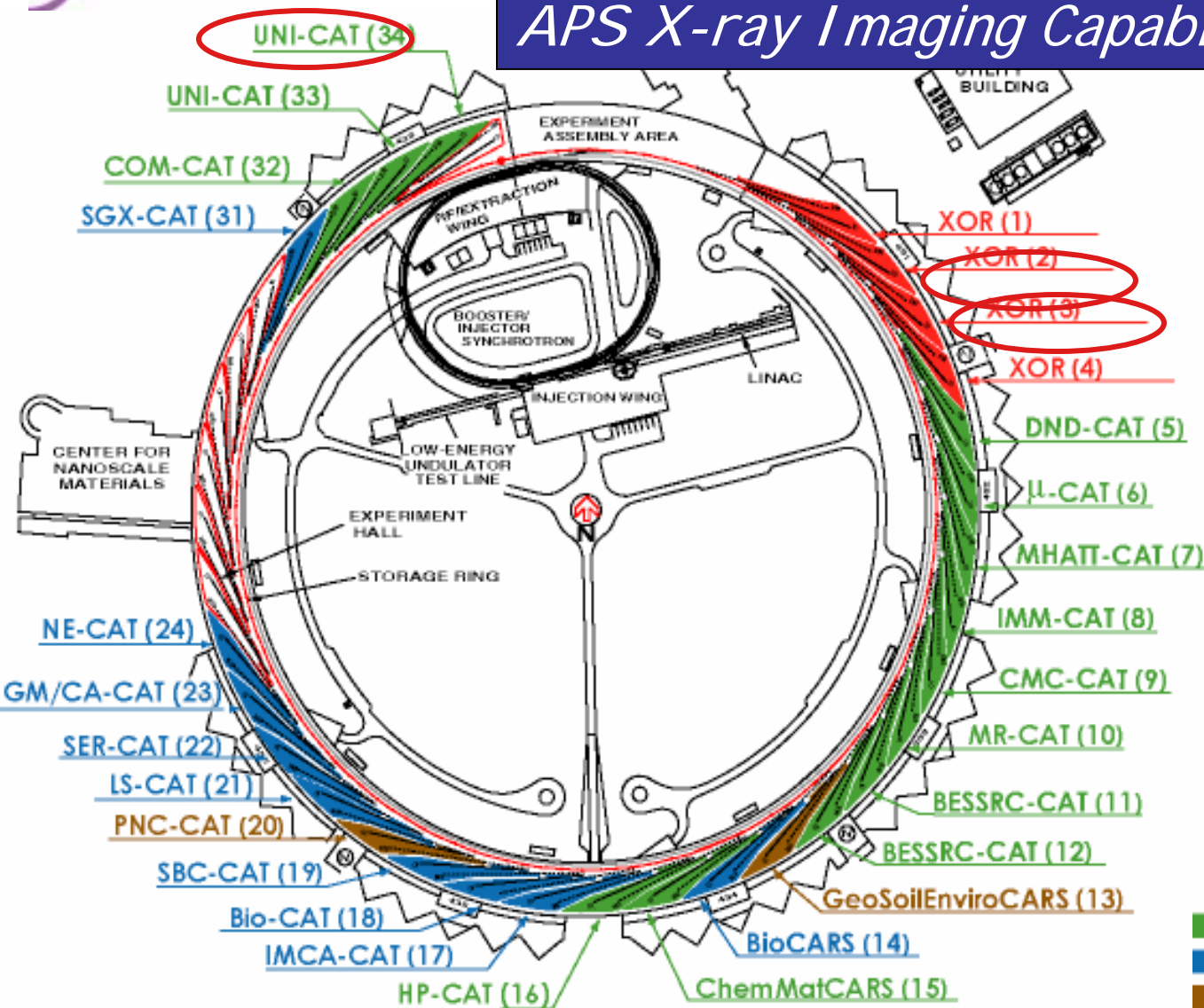


Practical Challenges

- *I identify scientific problems that are brilliance limited*
E.g., Temporal studies
- *Meeting the needs of a broad and diverse community*
E.g., Combining multiple techniques on a single beamline
- *Developing detectors **optimized** for various imaging methodologies*
- *R&D for X-ray Imaging Technique Development*
E.g., Exploring Phase Based Diffractive Methods
- *Image processing*
E.g., Handling in situ data analysis
- *Complexities of sample environment for in situ (in vivo) studies*
E.g., Life sciences samples

WORKSHOP ON EMERGING SCIENTIFIC OPPORTUNITIES USING X-RAY IMAGING

APS X-ray Imaging Capabilities



- XOR (S 1)
- XOR (S 2)
- UNI-CAT (S 34)

■ MATERIALS, CHEMICAL, & ATOMIC SCIENCE
■ BIOLOGY
■ GEO, SOIL, & ENVIRONMENTAL SCIENCE
■ INSTRUMENTATION

Draft Workshop Objectives

- 1. Explore the breadth of science covered by the workshop topics, *not* limiting to synchrotron techniques alone.**
- 2. Identify opportunities for continued scientific discovery and impact using the x-ray imaging at the APS during the next 5-10 years in the multi-disciplinary areas of science.**
- 3. Identify new scientific proposals/programs specific to the emerging areas using x-ray imaging that the participants will bring to the APS during next 5 to 10 years. Also evaluate the capital and operational requirements for these proposals/programs.**

Draft Workshop Objectives

- 4. In addition to available beamline capabilities at the APS, identify future needs to support research in this area of science and technology.**
- 5. Address detector R&D that will enhance the capabilities of the APS x-ray imaging.**
- 6. Address the need and support for developing imaging methodologies and image processing.**
- 6. Prepare a summary document for the archival literature to serve as a roadmap for the time domain research using x-rays at the APS Source and suggest the role of the Advanced Photon Source towards this objective.**